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An Estimate of the Source and Uptake of Nitrogen in Continuous No-Till Com Grain Production

Kenneth L. Wells
University of Kentucky

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE
Lexington, KY 40546-0064

COOPERATIVE EXTENSION SERVICE

Department of Agronomy

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Background

The U.S. Environmental Protection Agency (EPA) has established a maximum nitrate nitrogen (NO_3-N) content of 10 parts per million (ppm) for safe drinking water. Because of this, the effect of commercial nitrogen (N) fertilizers in agricultural production as a contributor of NO_3-N to surface and groundwater is now being widely examined. Since corn production in the US is the largest single source of fertilizer N use, averaging perhaps 100-150 lbs N/A on the 70-80 million acres of corn produced annually, an understanding of N utilization and losses in corn production is helpful in determining the role of N fertilization of corn as a potential groundwater contaminant. Concerns are greatest in areas where a large proportion of the landscape is used for corn production in any given year. For Kentucky as a whole, only 5.4% of the total land area was used for corn in 1993, ranging from less than 1% in eastern Kentucky to over 15% in parts of western Kentucky. Some individual counties were higher (Union 36%, McLean 27%, Henderson 26%, Daviess 26%, Webster 21%). At an estimated N use of 150 lbs/A, total N used on corn in these counties was 5,925; 3,300; 5,475; 5,700 and 3,375 tons, respectively. In order to provide for a better understanding of what happens when N is used for corn production, an estimate was made of source and uptake of N in a continuous no-till corn production system.

Basis of Estimate

Yield results from 13 consecutive years of a replicated no-till corn production study of N rate responses conducted at the UK College of Agriculture's Robinson Substation at Quicksand, Kentucky, were used as the basis for estimating N uptake by corn. Although grain yields were measured on these plots each year, they were not analyzed for N content. For making estimations of N content in the grain on an oven-dry basis (5.5% moisture), it was assumed that protein content would be 8.125%, which is the equivalent of 1.3% N. Based on the further assumption that 72% of the total N in a corn plant is in the grain, estimation was made of total N uptake, grain N, and stover N. These values were calculated for corn grown with 160 lbs N/A yr, except for 1992 and 1993, when N rate was 80 and 180 lbs N/A, respectively. Similar calculations were made for corn grown in the same study with no fertilizer N, and these values were assumed to represent the amount of N mineralized from the soil. These data are summarized in Table 1. Subtraction of N uptake by the no-N plots from that of the N plots provided N values that were considered to be the "apparent" N uptake from N fertilizer.

The soil at the research site was a Pope silt loam, which is a well drained bottomland soil, capable of high production. Corn was no-till planted each year into the previous year's crop residues. Harvest stands were 22,000-23,000 stalks per acre. Average grain yield for the 13 years was 165 bu/A, ranging from 134 (during an abnormally dry year) to 188. Yields were 155-188 bu/A during 10 of the 13 years.

Uptake of N

Estimated N uptake during the 13 years is summarized in Table 1. "Apparent" fertilizer N uptake was estimated to be 120 lbs/A/yr as compared to the average of 155 lbs/A of fertilizer N applied. Of the 120 lbs/A uptake of fertilizer N, 87 lbs/A was estimated to be in the grain and 33 lbs/A in the stover. Total mineralized N uptake was 38 lbs/A. Thus, 120 lbs N/A of the 158 lbs total N uptake was "apparently" from fertilizer and 38 lbs N/A

lbs/A/yr.

Summary

For 13 years of continuous production of no-till corn, an average of 193 lbs N/a were "available" each year, 114 lbs N/A were removed from the system each year in grain production, 44 lbs N/A were recycled into the system as plant residues each year, and 35 lbs N/A were unaccounted for and assumed to be either lost (leaching, volatilization, denitrification) or unavailable. It is leached N that would contribute to NO_3-N content of groundwater; the amount actually entering the groundwater would be related to soil conditions controlling leaching, denitrification, and volatilization, and amount of rainfall.

Results from this estimate indicate that 77% of the fertilizer N applied could be accounted for by corn uptake in the no-till system described. The 23% of fertilizer N unaccounted for is likely due to the combined effects of immobilization, leaching, denitrification, and volatilization. Estimated long-term fertilizer N uptake by continuous no-till corn grown under consistently favorable conditions was shown in this example to be very high.

Table 1. Grain Yield and Estimated N Uptake by No-Till Corn*

	160 lbs N/A**				No N			
		N Uptake (lbs/A)				N Uptake (lbs/A)		
Year	Grain Yield (bu/A)	Grain	Stover	Total	Grain Yield (bu/A)	Grain	Stover	Total
1981	185	128	50	178	33	31	12	43
1982	166	114	44	158	44	42	16	58
1983	156	108	42	150	41	39	15	54
1984	187	129	50	179	39	37	14	51
1985	172	118	46	164	23	22	9	31
1986	134	93	36	129	38	36	14	50
1987	160	110	43	153	21	20	8	28
1988	149	102	40	142	35	24	9	33
1989	188	130	50	180	21	14	6	20
1990	171	117	45	162	31	21	9	30
1991	155	107	42	149	41	28	10	38
1992	145	100	39	139	28	19	8	27
1993	180	124	41	165	25	17	7	24
Average	165	114	44	158	32	27	11	37

* Estimated by assuming 8.125% protein in grain (1.3% N), 72% of total N in grain, and oven-dry weight (5.5% moisture).

** N rate was 80 lb/A in 1992 and 180 lb/A in 1993.

Additions of N to the System

During the 13 years, 2,020 lbs/A of fertilizer N were used (Av. 155 lbs/A/yr). Available soil N (that mineralized from soil organic matter) was estimated from uptake of corn grown without fertilizer N. This averaged 38 lbs N/A for the 13 years. No attempt was made to estimate additions of N from precipitation, which some reports have indicated could be 5-15 lbs/A/year.

Table 2. Estimated N Balance for Continuous No-Till Corn*

		lbs N/A/Yr
Source of N		
Fertilizer		155
Apparent mineralization		38
	Total	**193**
Fate of N		
Harvested (grain)		114
Recycled (stover)		44
Apparent losses		35
	Total	**193**

* Average of 13 years continuous production.

Fate of N

The largest loss of N from the system was that contained in the grain, amounting to 114 lbs/A/yr. There are other likely losses from leaching and denitrification during periods when the surface soil is saturated with water, and volatilization of ammonia N (NH_3-N) from both the soil surface and from the plant. While immobilization of N by soil bacteria is not a net loss from the system, immobilized N is not available for plant uptake. No measurements were made of such losses, and they were estimated by subtracting total corn uptake of N (grain and stover) from total N added to the system (fertilizer N and soil mineralization of N). This amounted to 35

Kenneth A. Wells
Extension Soils Specialist

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